

Satellite-based Evapotranspiration Mapping in Idaho

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in partnership with
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Climate Impacts Group, Idaho Climate and
Water Meeting, Boise ID, November 2, 2010



Why is Evapotranspiration (ET) important

- ET is the water consumed by irrigated agriculture
- 3.4 million acres of irrigated agriculture in Idaho
- Over 90% of the water consumed is for irrigation
- Important for: water administration, water planning, and hydrologic modeling

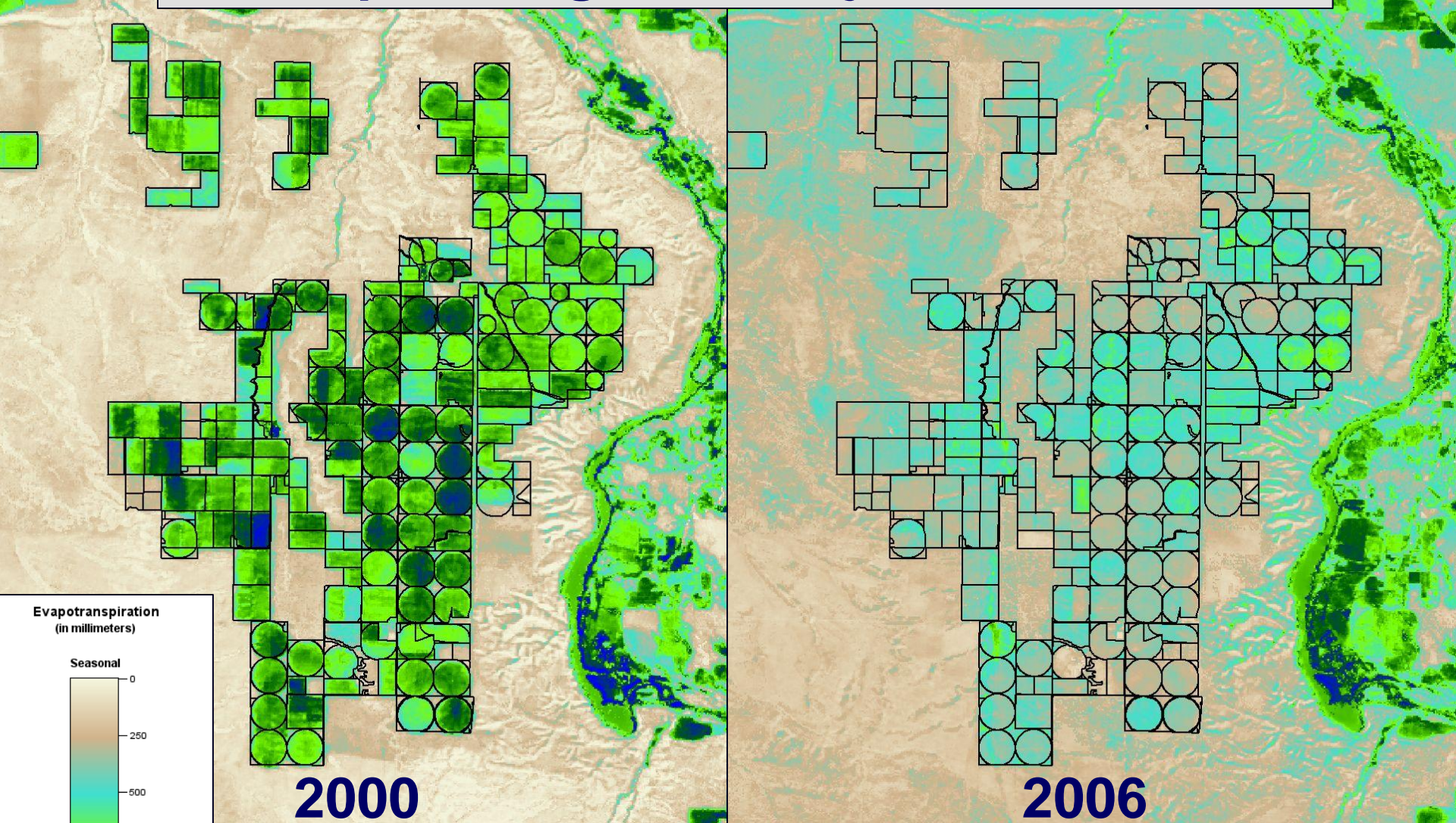
Ground-based ET

- Potential ET using crop coefficients
 - Needs crop type acres and stage of growth
 - Produces one ET value per county

Satellite-based ET

- Actual ET from Landsat using METRIC
 - No crop information required
 - ET per pixel can be summed by field

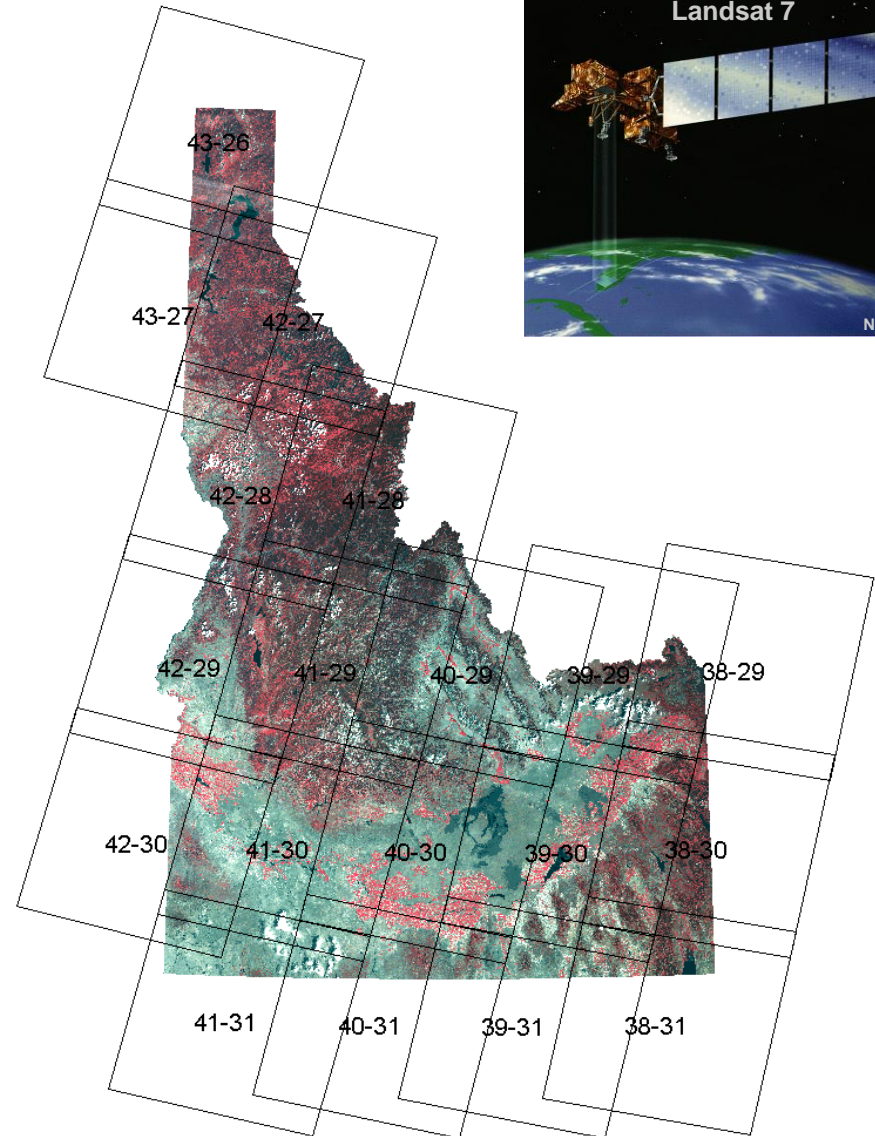
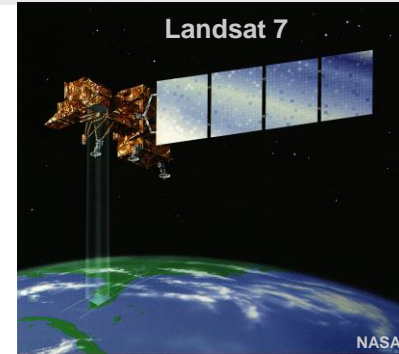
Bell Rapids Irrigation Project: Seasonal ET



- High lift pumps irrigated 25,000 acres
- State purchased water rights in 2005
- Supports endangered salmon

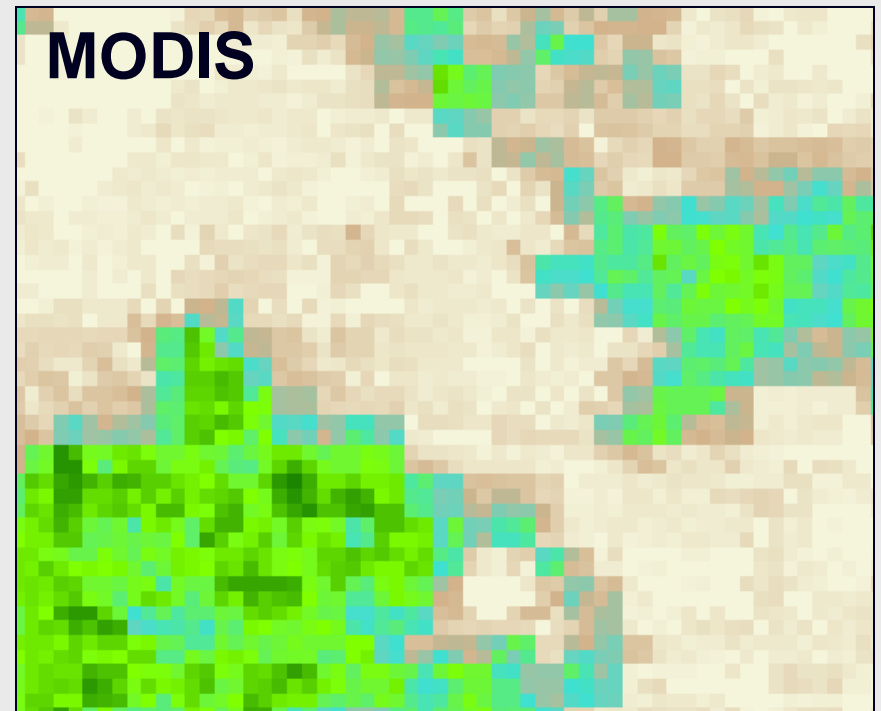
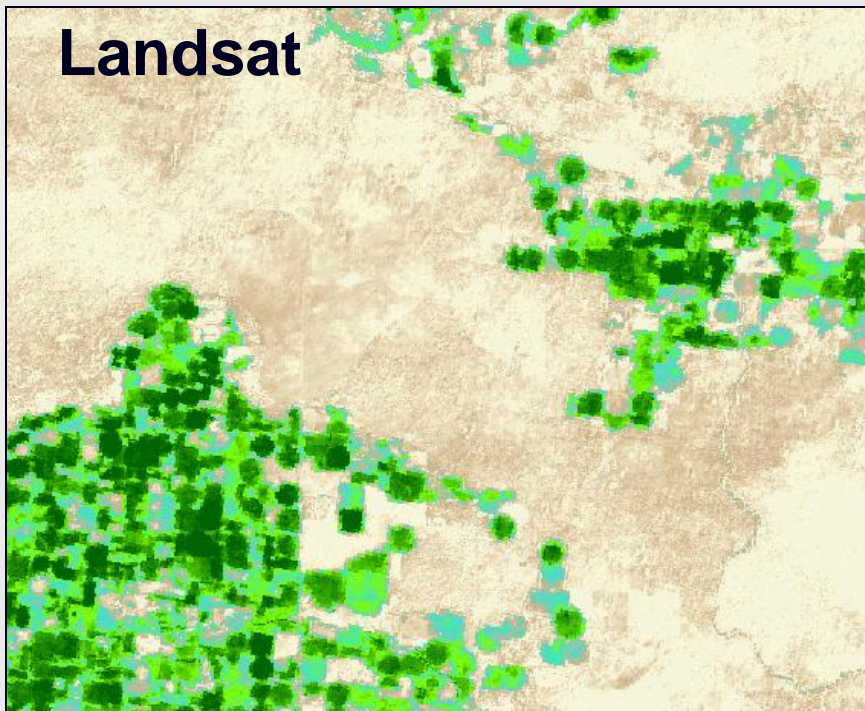
Landsat

- USGS/NASA mission
- L5 launched 1984
- L7 launched 1999
(damaged May, 2003)
- 30 meter pixels
- 16 day cycle
- 100 by 100 miles
- *Free*
- Landsat 8 will launch in December 2012



Why not use other satellites

- MODIS: 500 meter pixels
- AVHRR: 1000 meter pixels
- SPOT: no thermal band
- IRS AWiFS: no thermal band
- Aster: for research



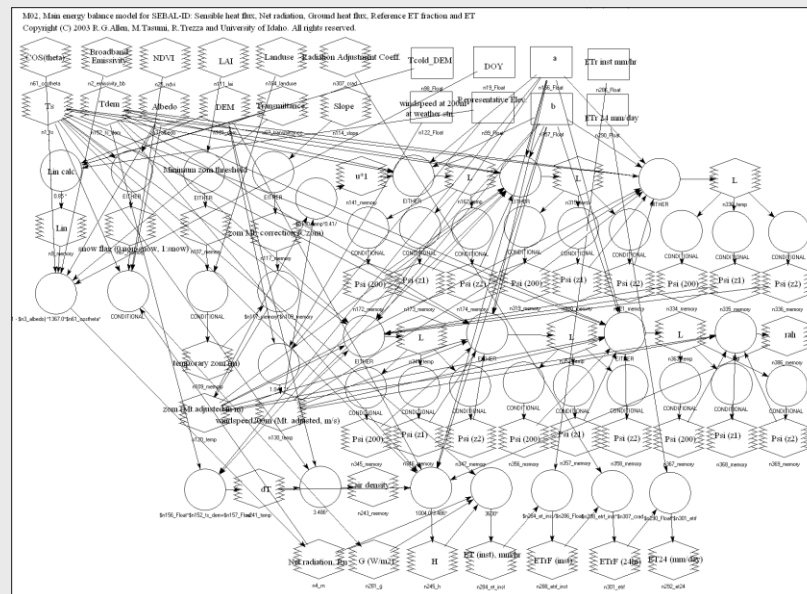
Landsat Thermal Band

- Required for surface temperature
- Landsat is the only operational satellite with a “thermal band” and a pixel size small enough to map ET for individual fields!

METRIC

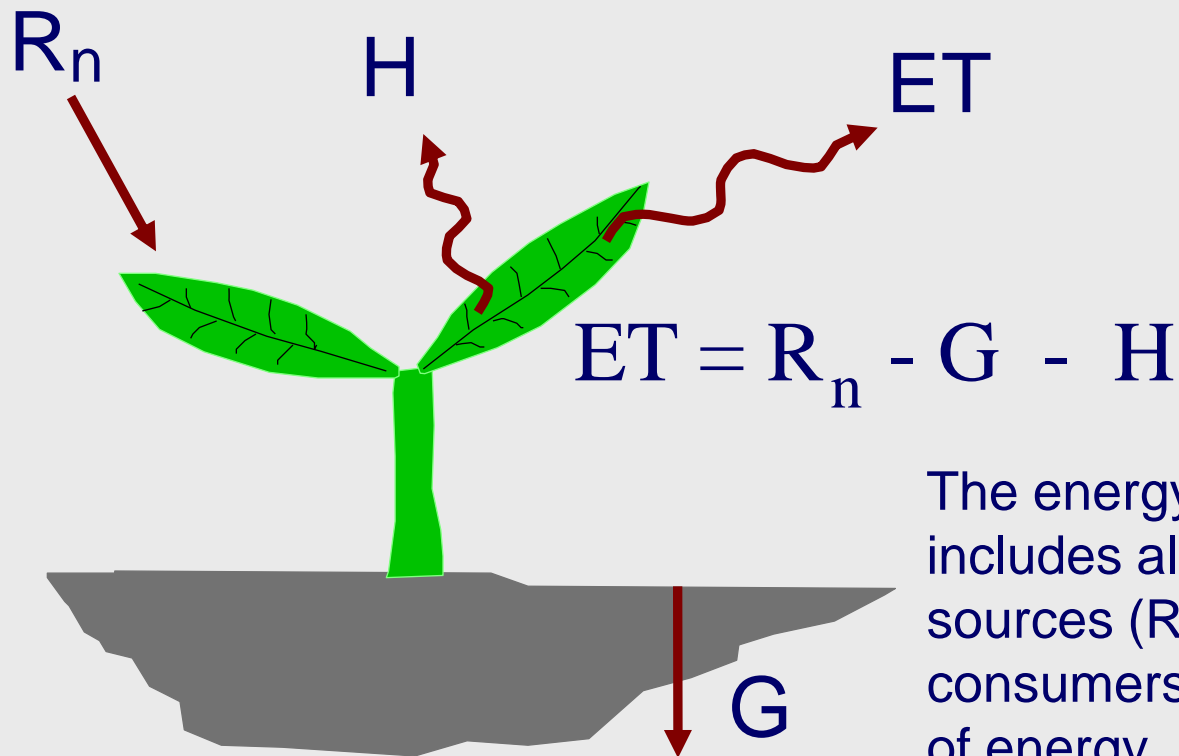
Mapping EvapoTranspiration at high Resolution with Internalized Calibration

- Satellite-based energy balance model that computes and maps actual ET
- Internalized Calibration ties down ET to weather data



Energy Balance for ET

- ET is calculated as a “residual” of the energy balance



The energy balance includes all major sources (R_n) and consumers (ET , G , H) of energy

Energy balance computes “actual” ET

Can ‘see’ impacts on ET caused by:

- water shortage
- disease
- crop variety
- planting density
- cropping dates
- salinity
- management



Weather Data

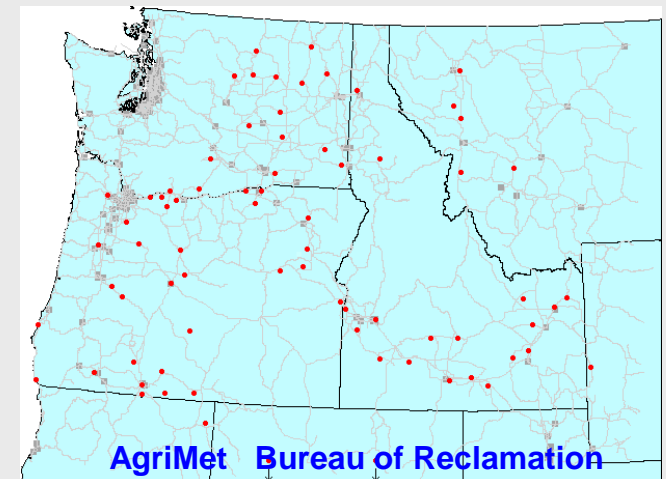
In METRIC, Weather Data are used for:

Wind speed for sensible heat flux calculation

Reference ET for calibrating the Energy Balance

Reference ET to extrapolate ET

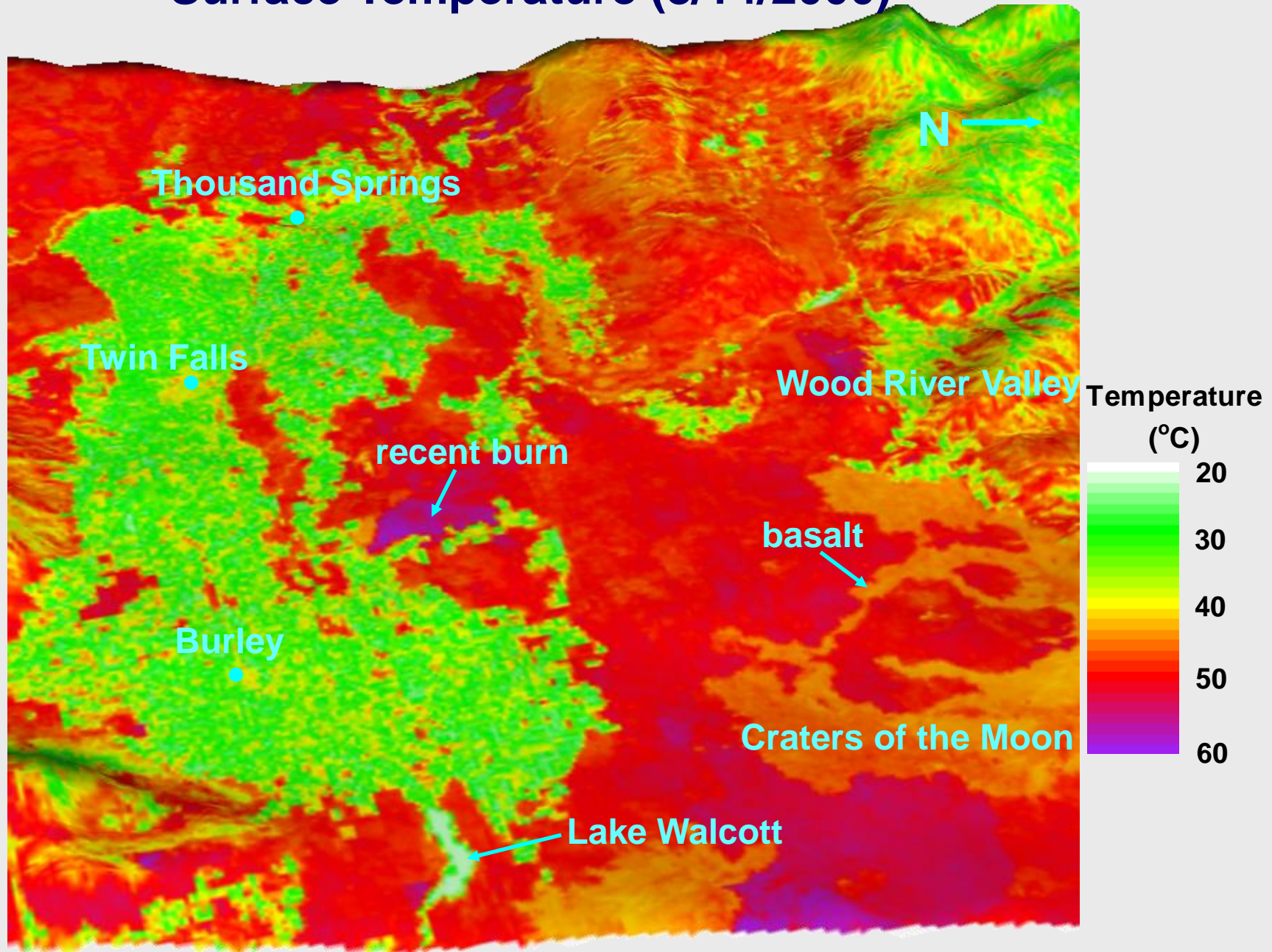
- 24-hour period
- Days between images



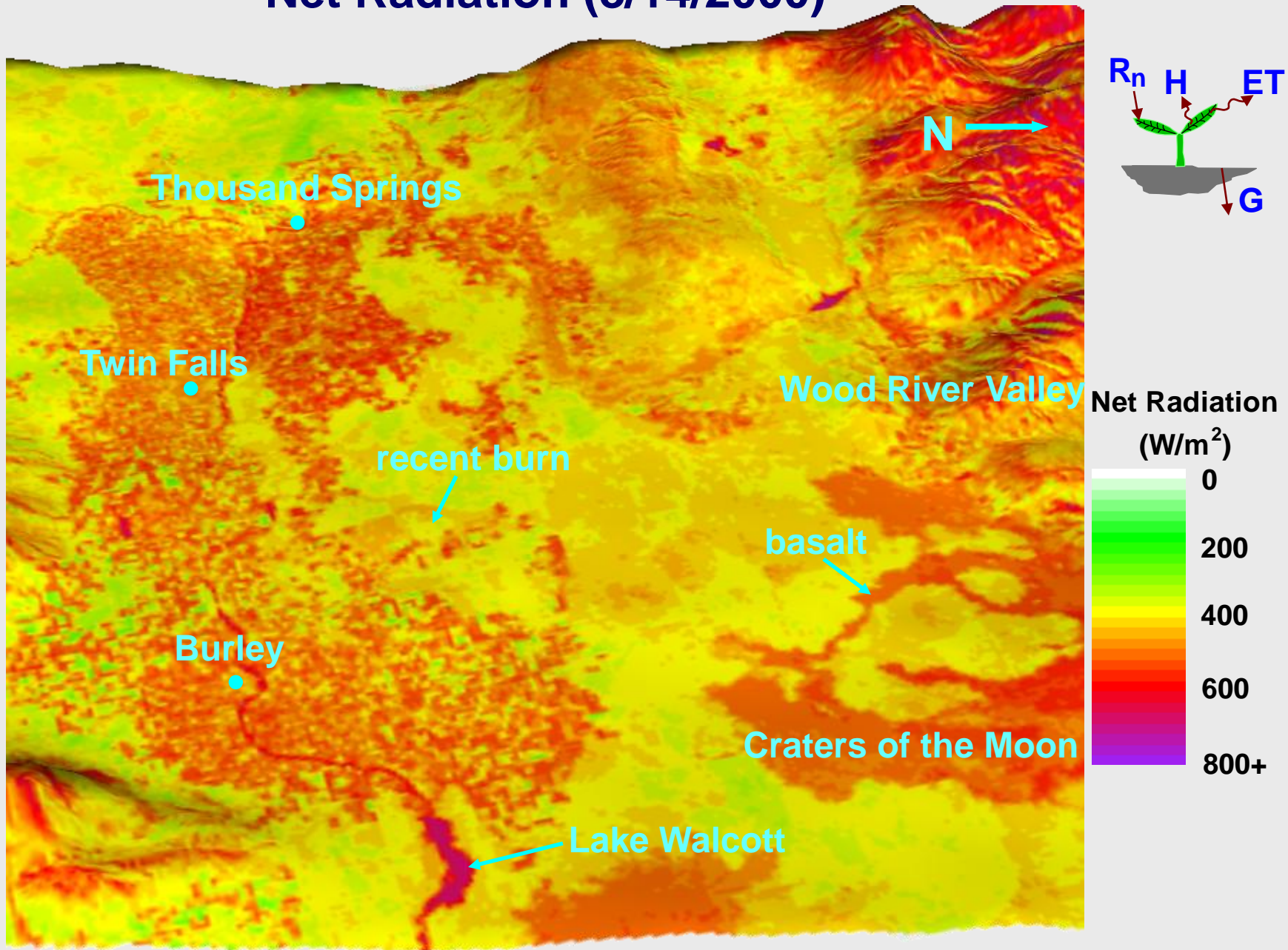
Landsat, south-central Idaho (8/14/2000)



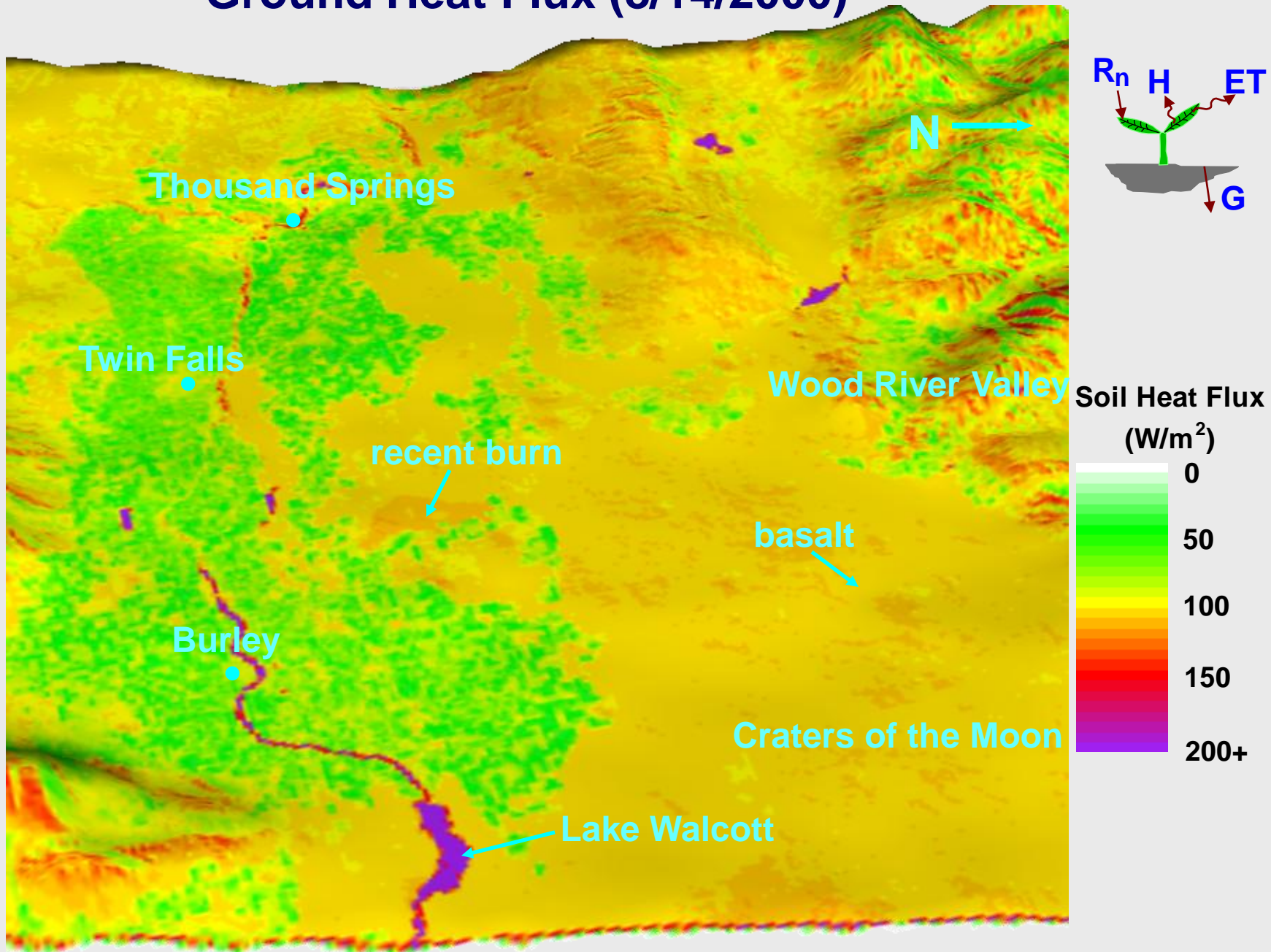
Surface Temperature (8/14/2000)



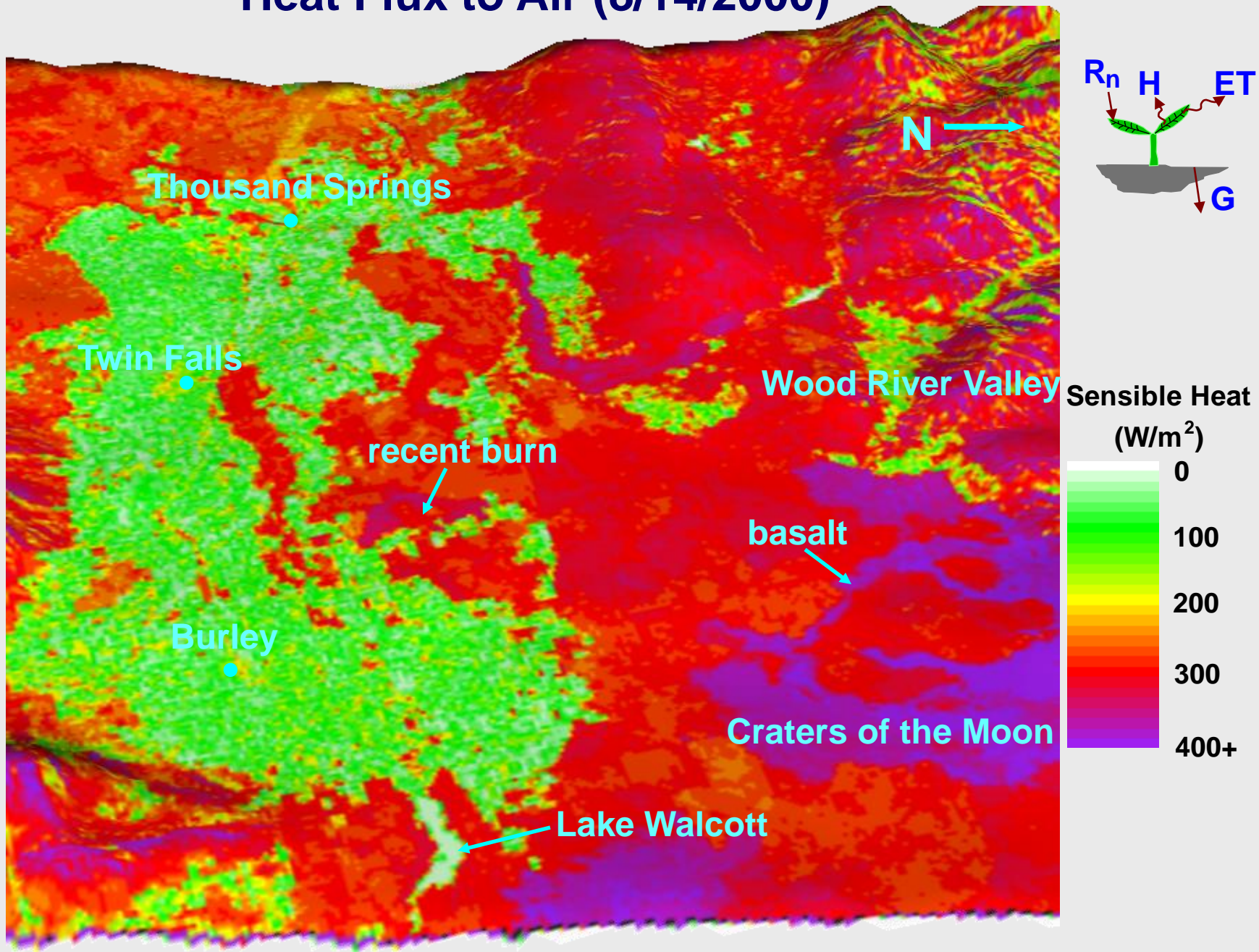
Net Radiation (8/14/2000)



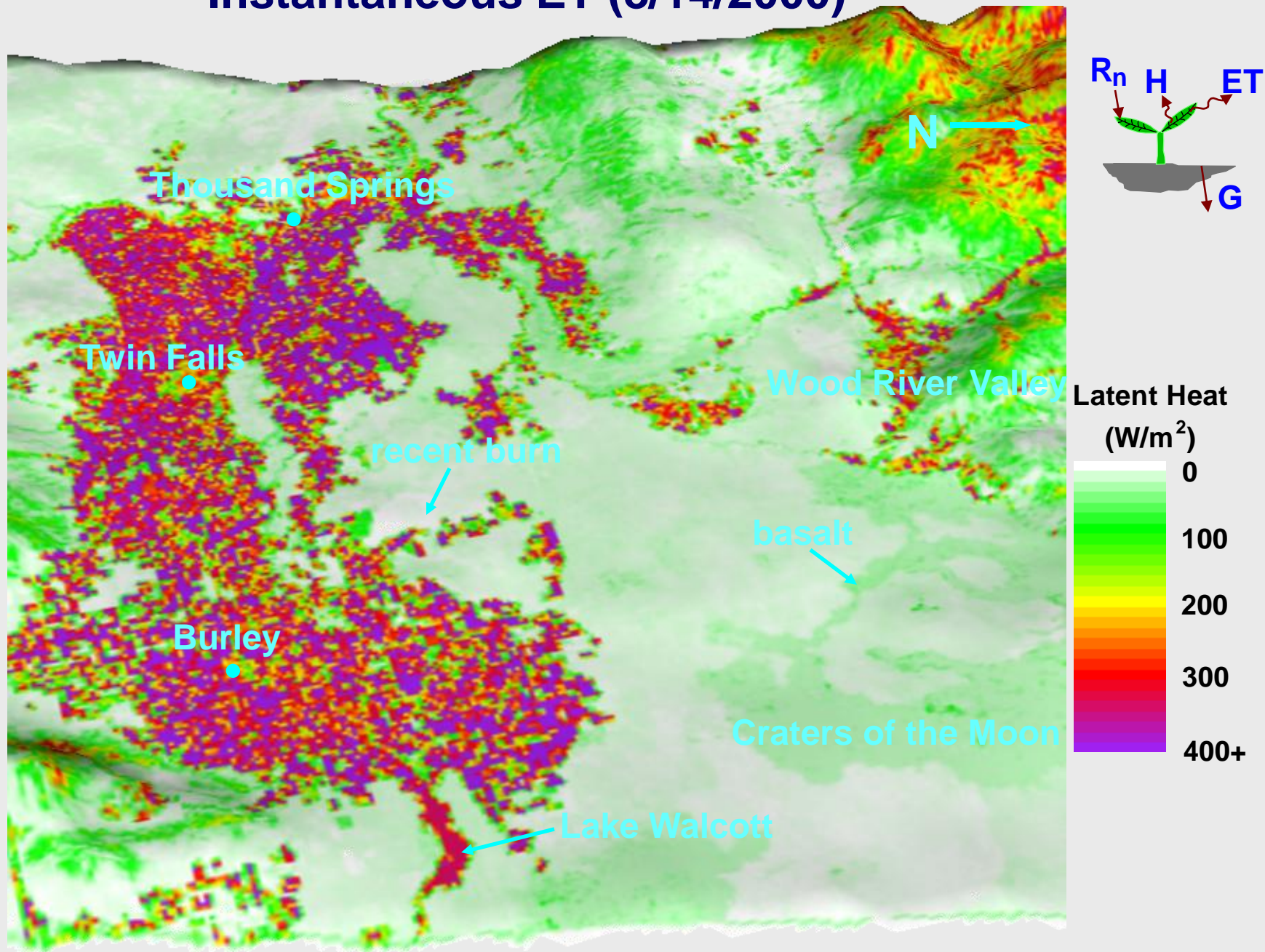
Ground Heat Flux (8/14/2000)



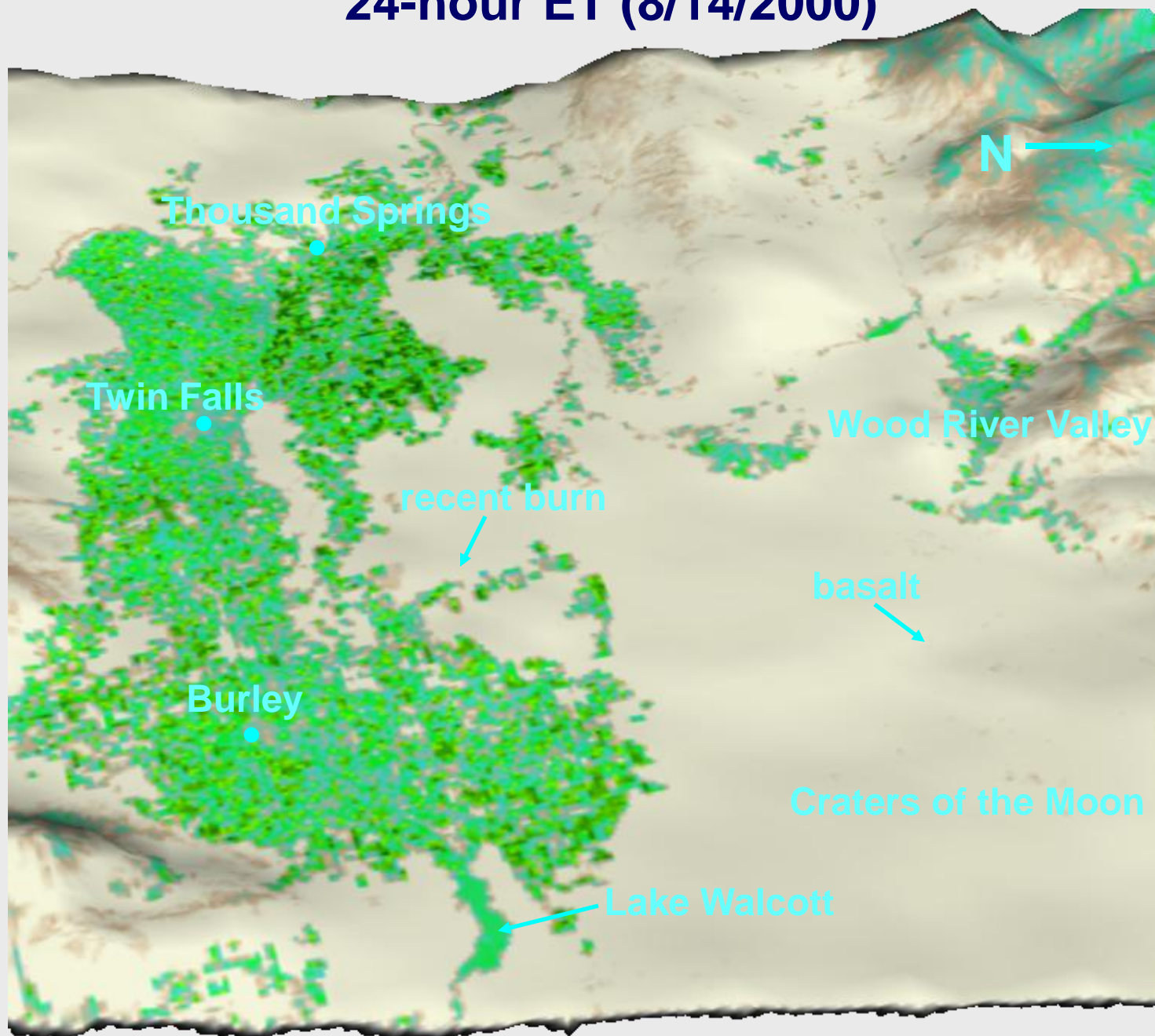
Heat Flux to Air (8/14/2000)



Instantaneous ET (8/14/2000)



24-hour ET (8/14/2000)



Evapotranspiration
(mm/day)



ETr Fraction



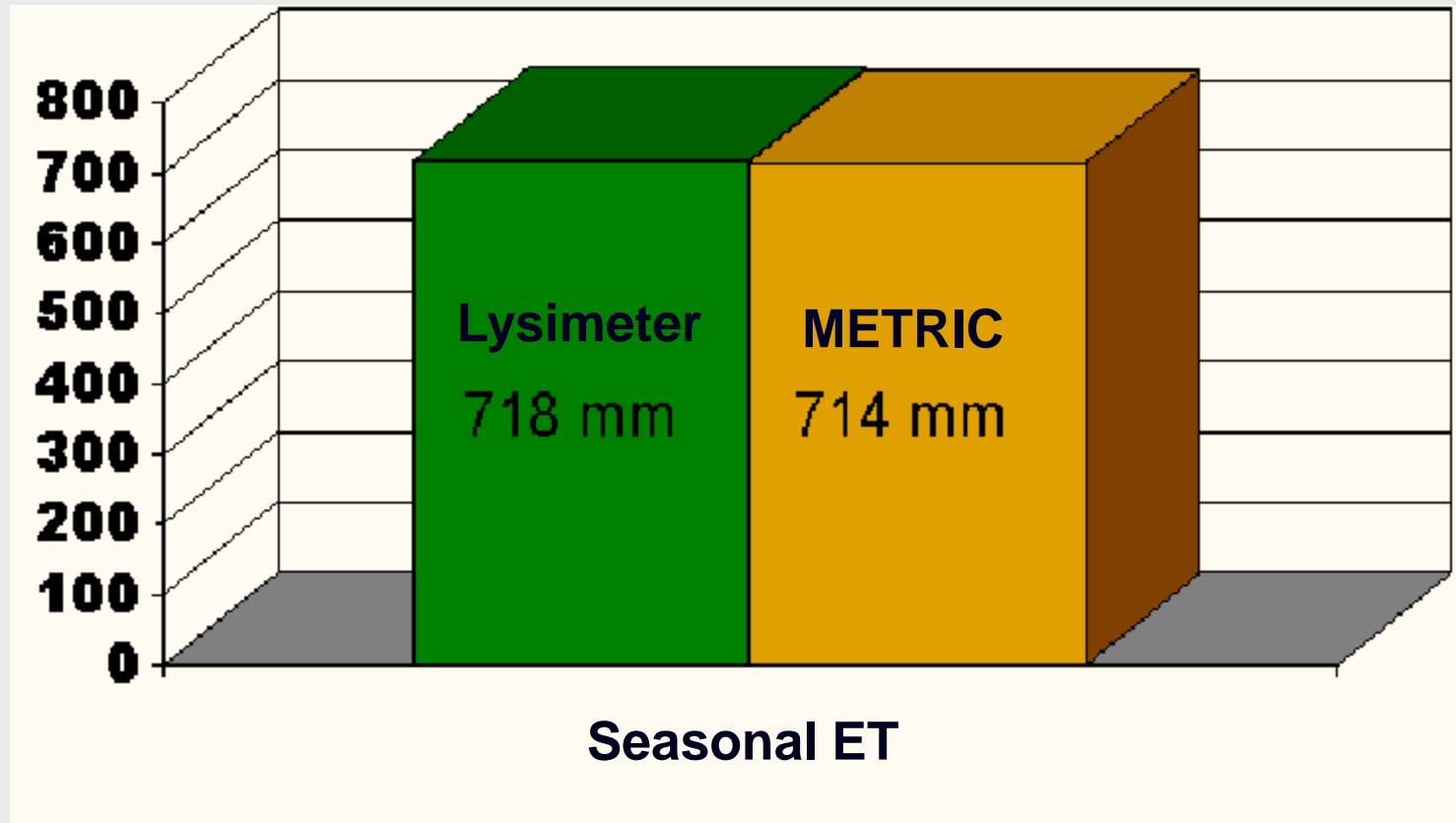
Comparison with Lysimeter Measurements



1968-1991



Lysimeter at Kimberly (Wright)



Comparison of seasonal ET as measured by lysimeter and computed by METRIC for sugar beets at the Kimberly Research Station, for April to September, 1989.

Applications in Idaho

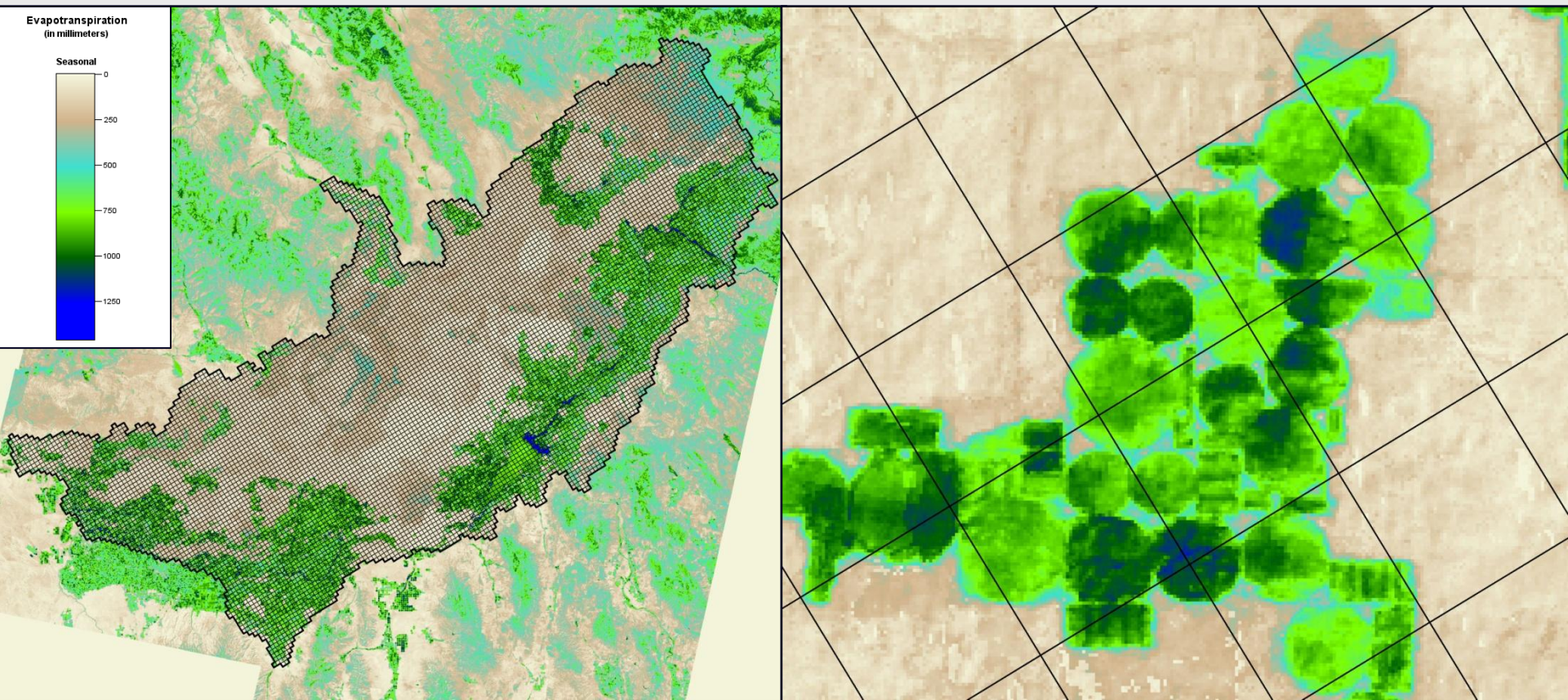
- Hydrologic modeling
- Water planning
- Water administration



Hydrologic Modeling

Eastern Snake Plain Aquifer Model

- Developing ET data from 1986 to present
- More accurately calibrate the groundwater model
- Completed for: 1996, 2000, 2002, and 2006



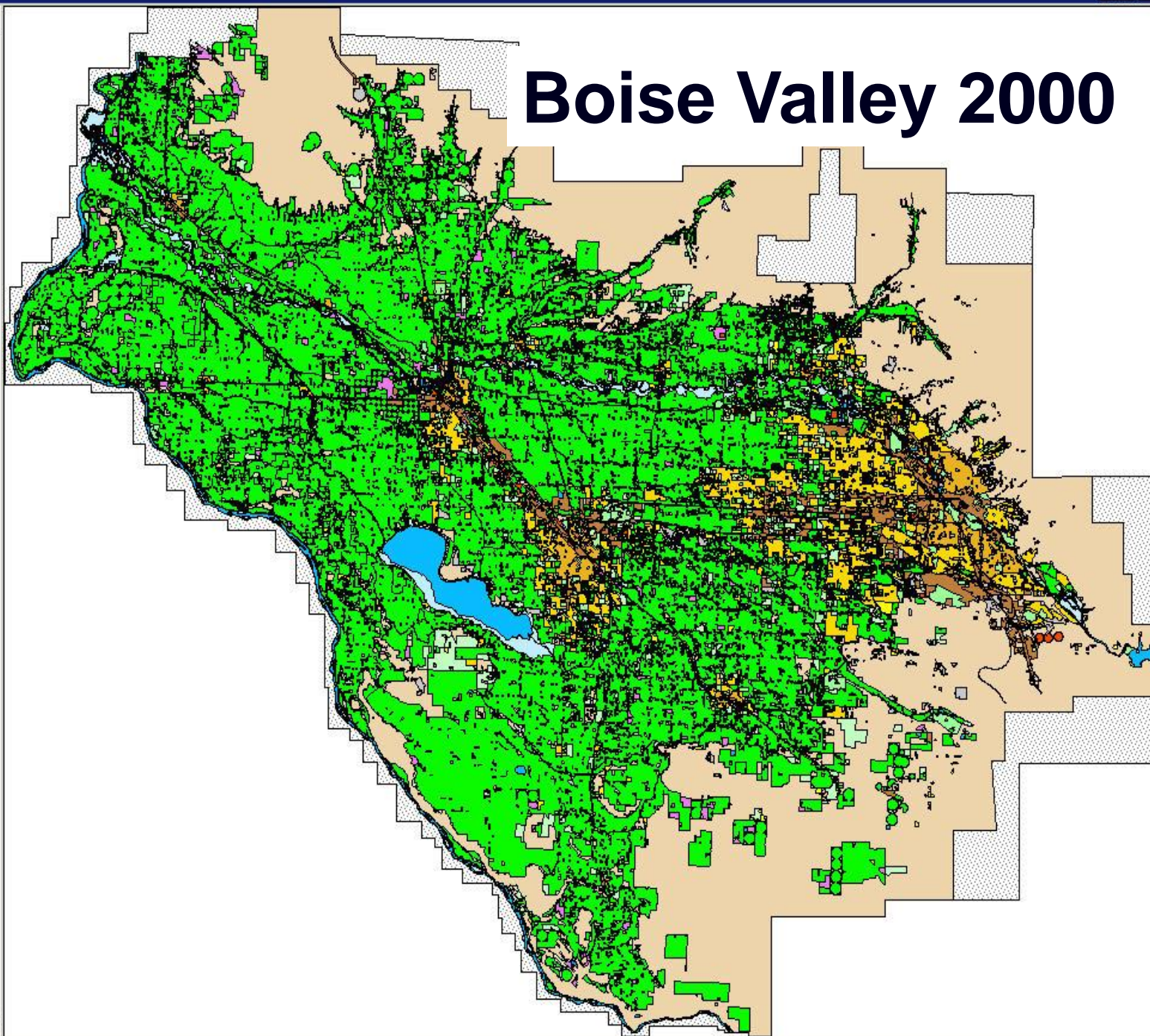
Water Planning

ET by Land Use

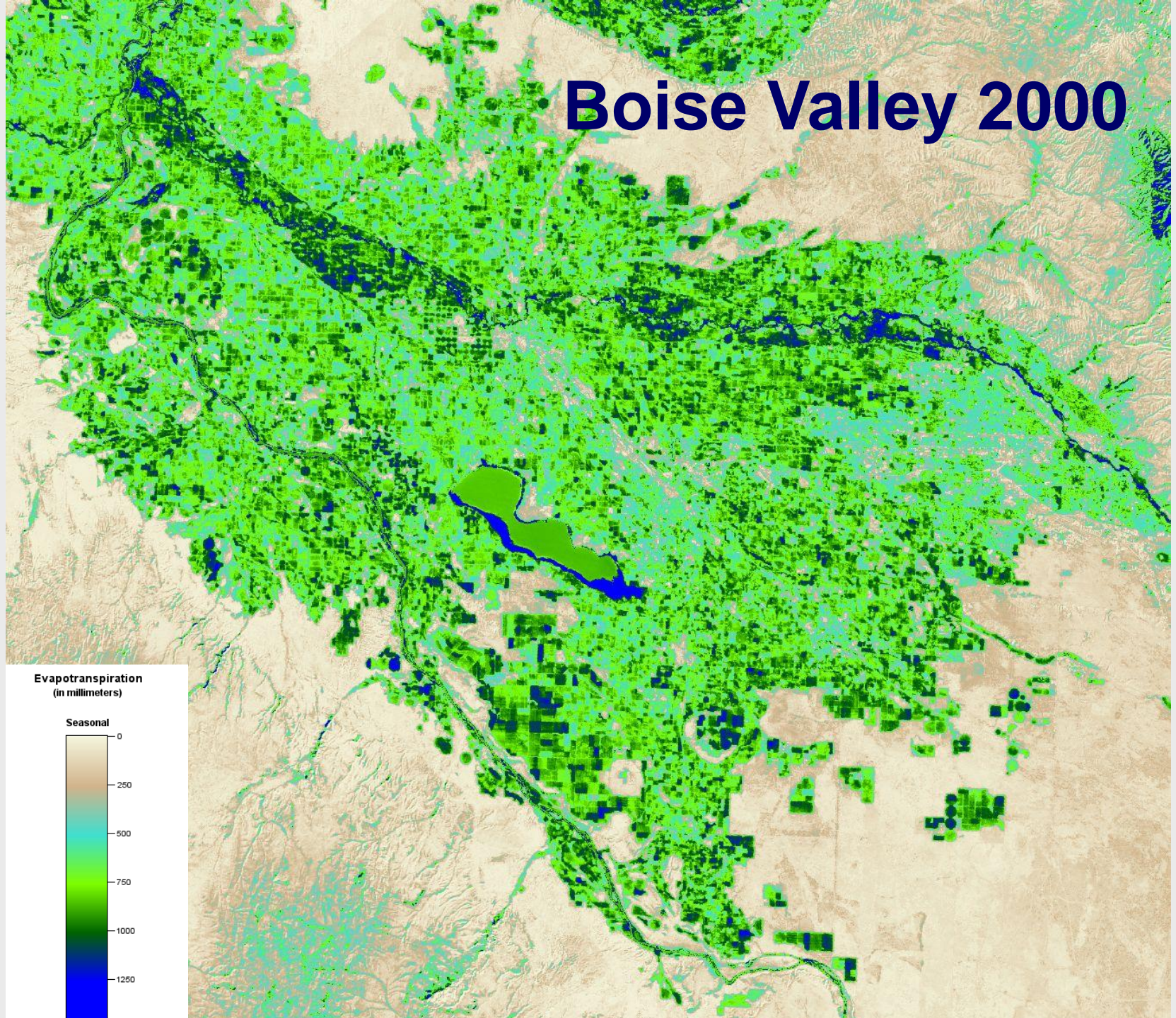
- Used for estimates of future water demand
- Year 2000 land use data analyzed with year 2000 seasonal ET data

Boise Valley 2000

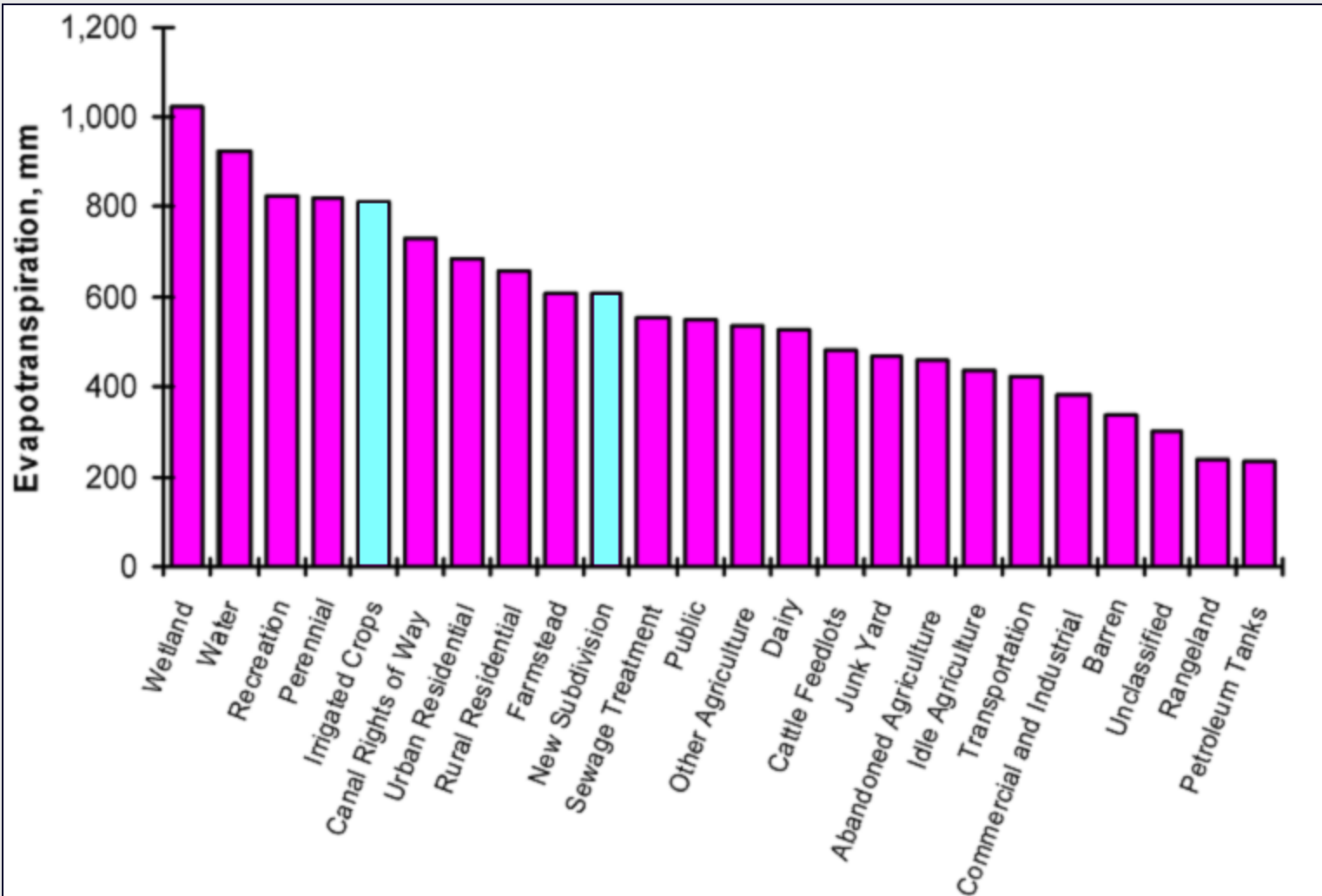
- ☐ Tv3994ird.shp
 - Irrigated 1994 and Irrigated
 - Irrigated 1994, Not Irrigated
 - Not Irrigated 1994, Irrigated
- ☐ Tv_94imagery.sid
- ☐ Tv2000.sid
- ☒ Tv_00landcov.shp
 - (12) Residential - Old Urban
 - (13) Residential - New Sub
 - (11,14) Residential - Farms
 - (15,18) Commercial/Industrial
 - (4,7) Water or Canals
 - (5) Wetland & Riparian
 - (16,17) Public or Recreation
 - (21,22) Agricultural Irrigated
 - (23,24,27,28) Agricultural
 - (25,26) Feedlot or Dairy
 - (3) Rangeland
 - (6) Barren Land
 - (19,81,82) Sewage Treatment
 - (99) Unclassified



Boise Valley 2000



ET by land use



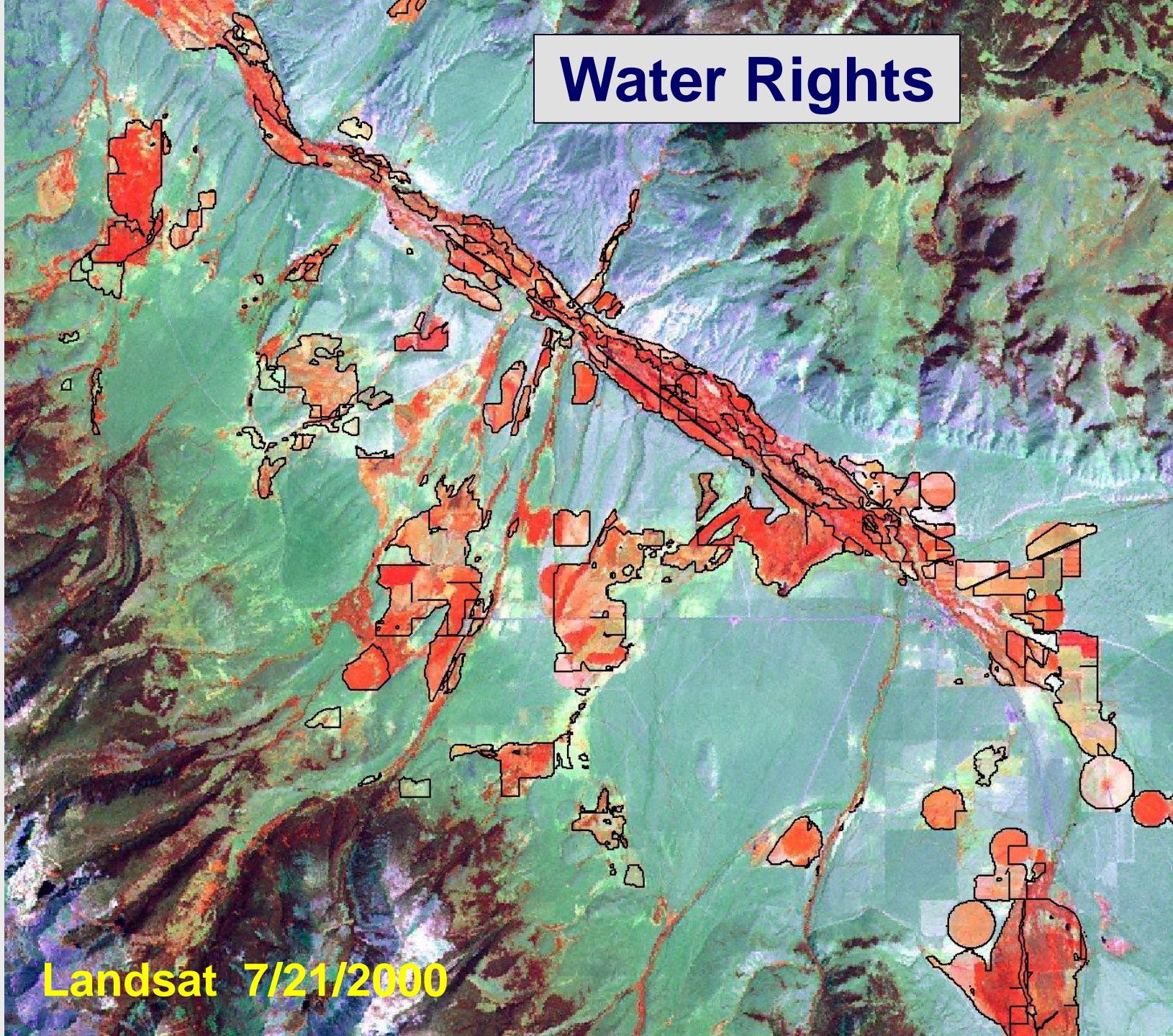
Water Planning

Endangered Species

- Landsat-based ET estimates volume of water consumed for irrigation of specific water rights
- Used to negotiate leases with irrigators to increase flows for endangered fish

Water Rights

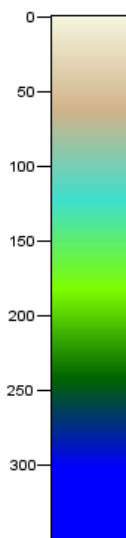
Landsat 7/21/2000



April

Evapotranspiration
(in millimeters)

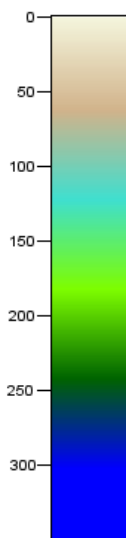
Monthly



May

Evapotranspiration
(in millimeters)

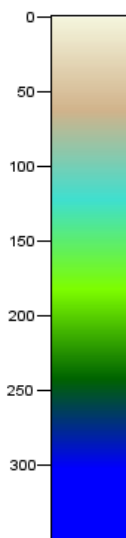
Monthly



June

Evapotranspiration
(in millimeters)

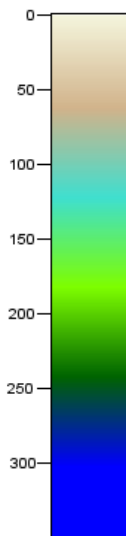
Monthly



July

Evapotranspiration
(in millimeters)

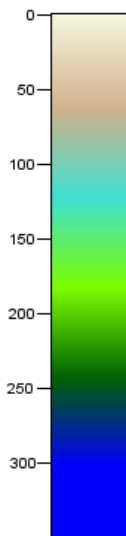
Monthly



August

Evapotranspiration
(in millimeters)

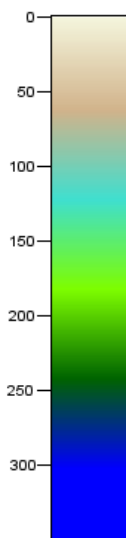
Monthly



September

Evapotranspiration
(in millimeters)

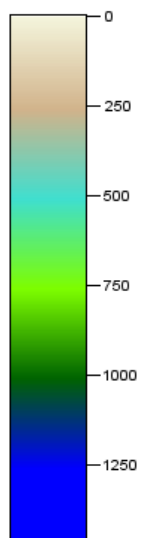
Monthly



Seasonal

Evapotranspiration
(in millimeters)

Seasonal



19,997 acres of irrigated land

33,520 acre-feet of ET for the year 2000 season

- (11 Billion gallons)

- (41 Billion liters)

Water Administration Litigation

- Clear Springs Foods water call
- A&B Irrigation District water call

Water Law Terms

- Water Right
 - Authorization to use water
 - Includes priority date
- Call
 - When a senior water right holder experiences a water shortage they may place a call
- Curtailment Order
 - Defines how the state directs junior water right holders to stop diverting water in response to a call
- Mitigation Plan
 - Junior users response to a curtailment order

Clear Springs Foods Water Call

Idaho *Business News*

Water curtailment ordered in Magic Valley

POSTED: 11:13 MDT Thursday, July 23, 2009

by IBR Staff

Idaho Department of Water Resources Interim Director Gary Spackman on July 22 issued a **curtailment order** to about 250 holders of 315 junior water rights in south central Idaho's Magic Valley. The curtailment order is part of a continuing response to a water delivery call made in 2005 by senior water right holder Clear Springs Foods.

State goes ahead with first large-scale well closure of more than 300 water rights in M.V.

7/31/2009

Water districts have limited options, could file a stay

By Nate Poppino

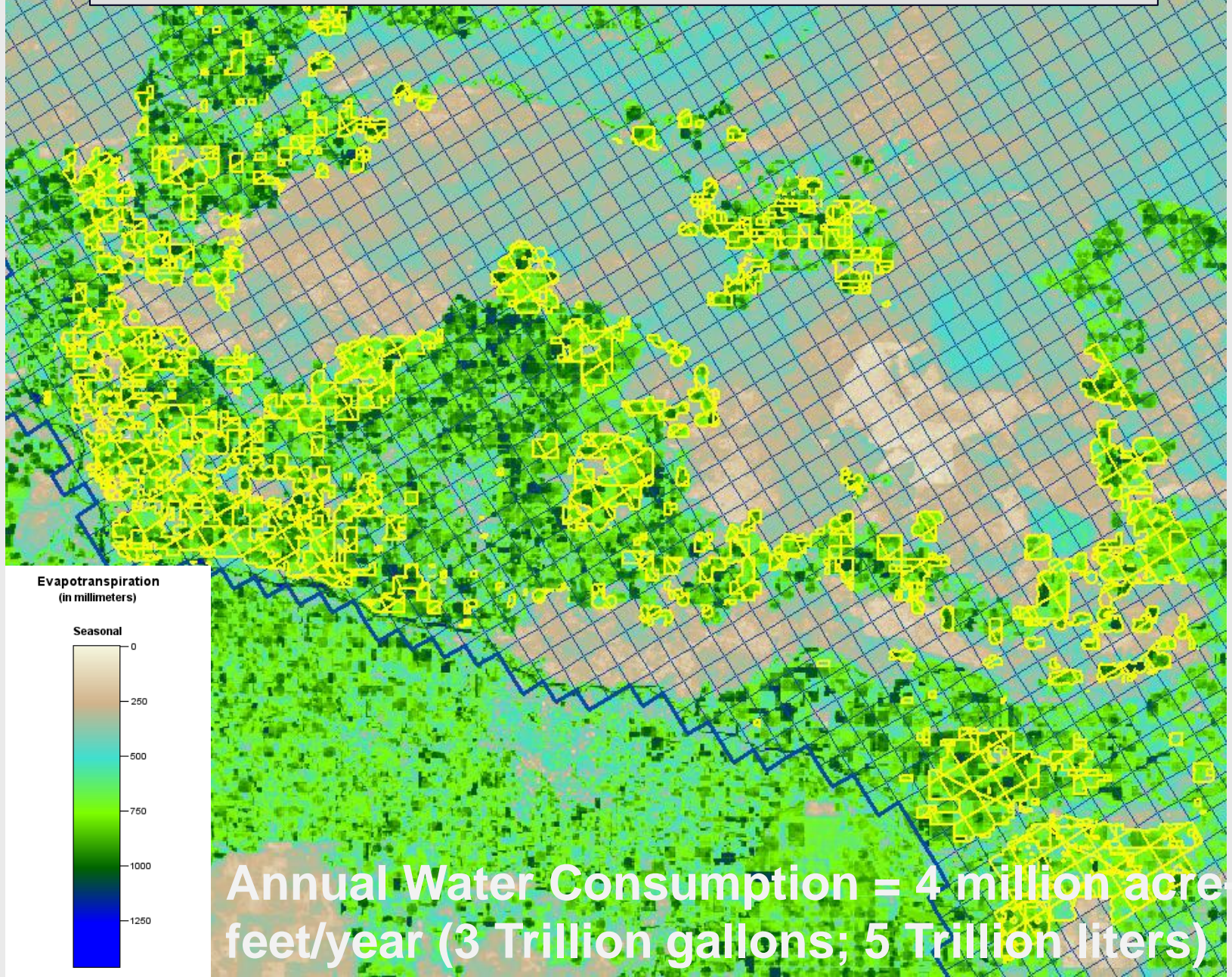
Times-News writer

The Idaho Department of Water Resources will go forward this morning with a plan to shut off more than 300 water rights irrigating just less than 9,000 acres of Magic Valley farmland, the first wide-scale well curtailment to actually be carried out by the state.

Clear Springs Foods, Inc.



METRIC ET 2006 April to October




Clear Springs Foods Water Call

Summary

- ESPA GW model used METRIC ET data
 - For model calibration
 - To select water rights to curtail
- No complaints from junior users about GW model or METRIC ET data


A&B Irrigation District Water Call

- A&B claimed that certain fields were short of water due to diversions from junior ground water users
- METRIC ET showed that the fields had ET rates as high as surrounding fields that were not identified as water short


 A&B Irrigation District

Irrigation Source


 A&B Irrigation District, ground water

 A&B Irrigation District, ground water, Item-G-land

 A&B Irrigation District, surface water

 North of A&B Irrigation District, ground water

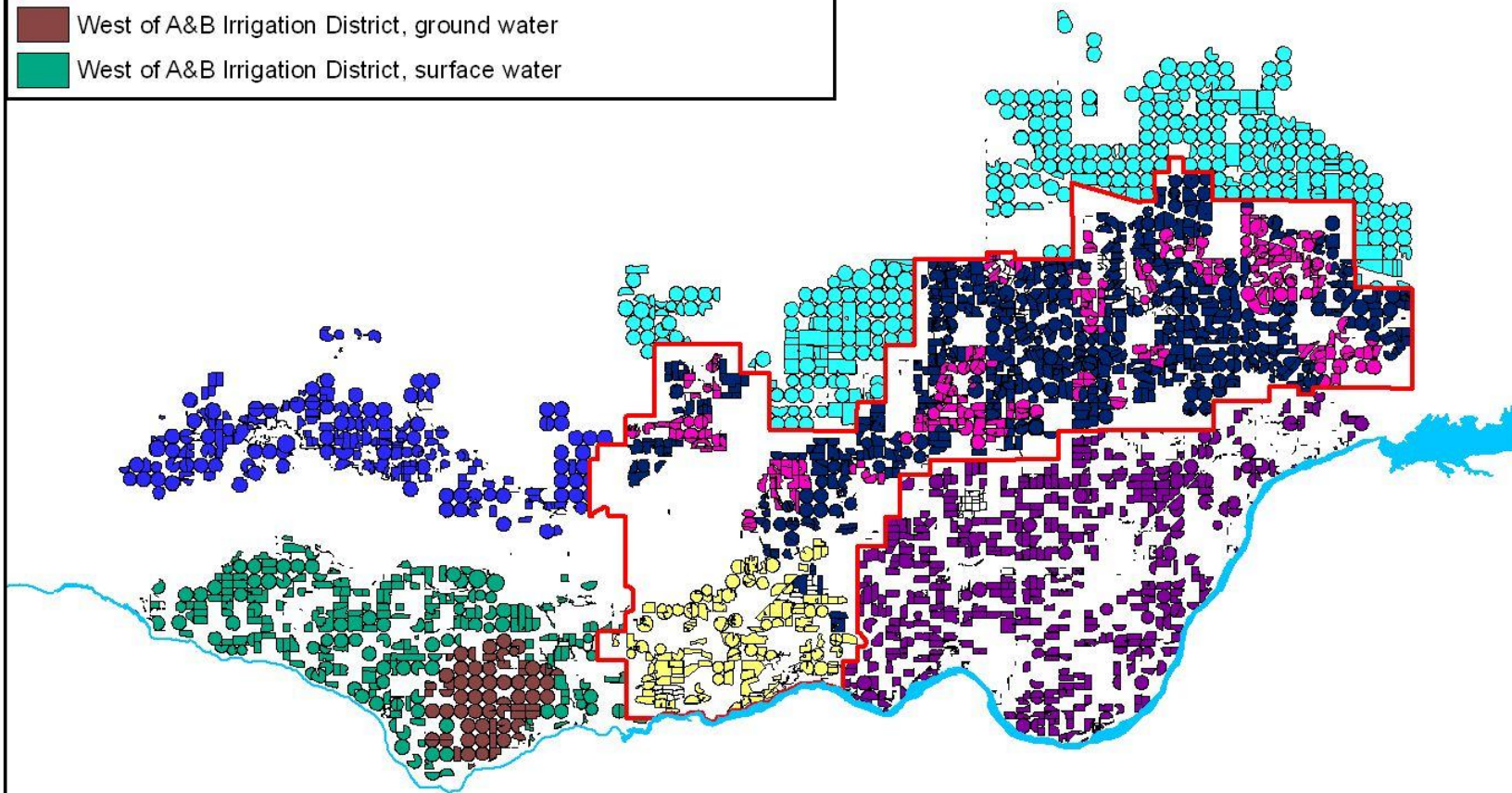
 Northwest of A&B Irrigation District, mixed surface and ground water

 South of A&B Irrigation District, surface water

 West of A&B Irrigation District, ground water

 West of A&B Irrigation District, surface water

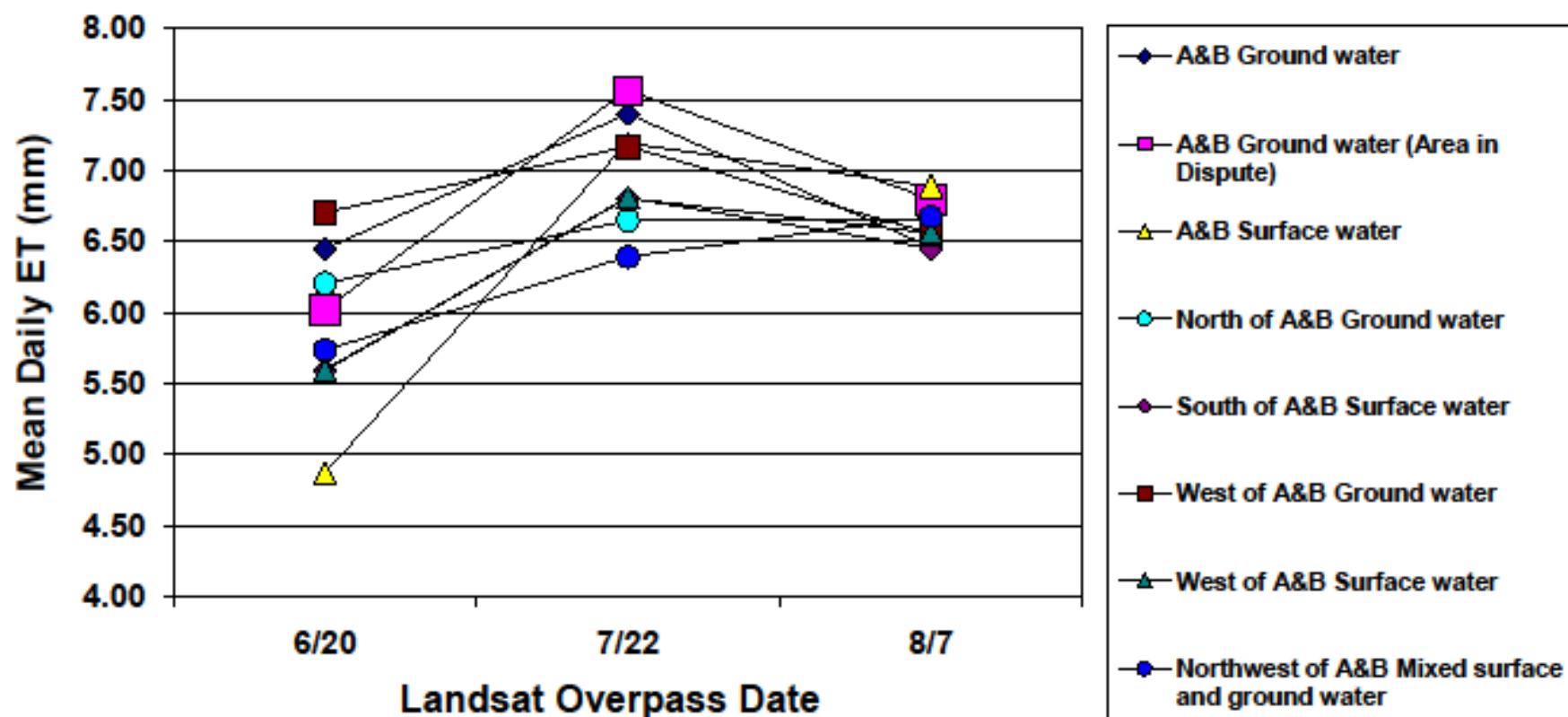
A&B Irrigation District and adjacent land



0 5 10 20 Kilometers



Year 2006: Mean Daily Evapotranspiration (ET)



Other states using or gearing up to use METRIC

- Nevada
 - Water transfers to Reno and Las Vegas
- Nebraska
 - Over pumping of the Ogallala Aquifer
- Colorado
 - Kansas vs. Colorado over Arkansas River
 - Nebraska vs. Colorado over S. Platte River
- Wyoming
 - Nebraska vs. Wyoming over N. Platte River
- Oregon
 - Klamath Basin water shortages
- California
 - Imperial Irrigation District: water consumption by irrigation
- New Mexico
 - Middle Rio Grande: water consumption by agriculture and riparian systems
- Montana
 - Flathead Indian Reservation and ground water areas east of Helena: for improved irrigation water management and management of total depletion

More Information

www.idwr.idaho.gov/GeographicInfo/METRIC/et.htm

www.kimberly.uidaho.edu/water/metric

Snake River Plain

